Wound Assessment System for Diabetic Patients

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Abstract – Foot ulcer represents a significant health issue for diabetic patients. Currently, doctors and nurses mainly assess their wound based on visual examination of wound size and healing status. Hence, a more quantitative and cost-effective examination method that enables the patients for daily wound care can accelerate wound healing, save travel cost and reduce healthcare expenses. In this paper, the proposed novel wound image analysis system implemented solely on the system. Firstly, wound image should present in the system. After that, the system should perform wound segmentation by applying the accelerated mean-shift algorithm. Specifically, the outline of the foot is determined based on skin color, and the wound boundary is found using a simple connected region detection method. Within the wound boundary, the healing status is next assessed based on red–yellow–black color evaluation model. The processing algorithm of Mean Shift Algorithm & K-mean Algorithm both are Accurate & well suited for the available hardware & computational resource that can be provided by the candidate through image capture & image processing.

Keywords – Image processing, mean shift, k- means, diabetic patients, wound analysis.

I. INTRODUCTION

For every individual with Type 2 diabetes, foot ulcers play a significant health issue which is affecting 5–6 million individuals in the US [1], [2]. Foot ulcers are painful, infection and very slow to heal [3], [4]. According to the published statistics, diabetes-related wounds are the primary cause of non traumatic lower limb amputations with approximately 71,000 people, such amputations in US is in 2004 [5]. Moreover, the cost of treating diabetic foot ulcers is almost at $15,000 per year per individual. So, overall diabetes healthcare cost was estimated around $245 billion in 2012 and is expected to increase in the next coming years [5].

There are several issues with current practices for treating diabetic foot ulcers. First, patients must go to their wound clinic on a regular basis where they will check their wounds checked by their clinicians. This need for frequent clinical evaluation is not only inconvenient and time consuming for patients and clinicians, but also represents a significant health care cost because patients may require special transportation, e.g., ambulances. Second, a clinician’s wound treatment process is based on visual examination. So, he/she describes the wound only by its physical dimensions and the color of its tissues, which providing important indications of the wound type and the stage of healing [6]. Because the visual assessment does not produce objective measurements and quantifiable parameters of the healing status [7], and tracking a wound’s healing process across consecutive visits is a difficult task for both doctors and patients.

II. RELATED WORK

In [8] Sarah Ostadabbam et al. proposed, the criticality of sensor architectural tradeoff in developing the in-shoe planar pressure monitoring systems. It evaluate the tradeoff by using our custom-made platform for data collection during normal walking. Tradeoff also showed the smaller sensors underestimate the total force and may not be placed well to receive the peak pressure. On the other hand, the larger sensors, are more likely to contain the peak pressure, but the reading may be a significantly under-estimation of the peak pressure.

In [2] A.Suresh et al. proposed, the Chan-Vese active contour based method for medical purpose to easily identifying of ulcer affected area in a foot of a diabetic patient. Chan-Vese active contour method was used for segmentation. It took into account as of visualization of the diabetic ulcers in the foot and used segmentation and represented with effective ulcer area with color and also in grey color images.

In [9] Simerjit Singh et al. proposed, Diabetic foot ulcer is characterized by a classical triad of neuropathy, ischemia, and infection. Each of these has a multi-factorial aetopathogenesis. These factors are compounded by mechanical stress created by foot deformities. The most commonly used classification systems are the Wagner-Ulcer Classification system and the University of Texas Wound Classification. These classifications help to predict the outcome of the condition. Prevention of this condition is paramount to prevent long term morbidity and sometimes mortality.

In [18] Plassmann P, Jones TD, proposed accurate measurement of the physical size of wounds is vital for assessment of the progress of healing. So technology employing image analysis techniques is a potential solution to both these problems.

III. PROPOSED SYSTEM

The diabetes foot ulcer Scheme is classified into following technique:

- Wound Image Analysis System Overview.
● Mean-Shift-Based Segmentation Algorithm.
● Wound Boundary Determination and Analysis.

In the Image preprocessing step, we first down size the sample from the high-resolution bitmap image which will speed up the subsequent image analysis. To eliminate excessive details it may complicate wound image segmentation. In our case, we download the original image (pixel dimensions 3264 × 2448) by a factor 4 in both the horizontal and vertical directions to pixel dimensions of 816 × 612, which has proven to provide a good balance between the wound resolution and the provides processing efficiency.

To determine the boundary of the wound area, we first determine an outline of the foot within the image. Hence, the initial Image segmentation is to divide the original image into pixel groups with homogeneous color values. Specifically, the foot outline detection is performed by finding the largest connected component in the segmented image under the condition that the color of this component is similar enough to a preset standard skin color. Based on the standard color checkers provided in [10], both the light and dark skin color thresholds in CIE LAB space are incorporated into the system, which means that our algorithm is expected to work for most of the skin colors. Afterwards, we have done wound boundary determination based on the foot outline detection result. The foot detection result is regarded as a binary image with the foot area marked as “white” and rest part marked as “black,” and it is easy to locate the wound boundary within the foot region boundary by detecting the largest connected “black” component within the “white” part. If the wound is located at the foot region boundary, then the foot boundary is not closed, and hence the problem becomes more complicated.

When the wound boundary has been successfully determined and calculated, we next evaluate the healing state of the wound by performing color segmentation, with the goal of categorizing each pixel in the wound boundary into certain classes labeled as granulation, slough and necrosis [11], [14]. The classical self-organized clustering method called K-mean with high computational efficiency used [12]. After the color segmentation, a feature vector including the wound area size and dimensions for different types of wound tissues is formed to describe the wound. This feature vector, along with both the original and analyzed images, is saved in the result database.

B. Mean-Shift-Based Segmentation Algorithm

The mean-shift algorithm, proposed in [15], better than the other segmentation methods. The mean-shift filtering algorithm is suitable for parallel implementation since the basic processing unit is the pixel. The mean-shift algorithm belongs to the density estimation based on nonparametric clustering methods, in which the feature space can be considered as the empirical probability density function which represented as parameter. In this mean-shift algorithm models the feature vectors associated with each pixel (e.g., color and position in the image), such samples from an unknown probability density function f(x) and then find clusters in this distribution. The center for each cluster is called the mode [14]. Given n data points xᵢ, i = 1,.., n the d dimensional space Rₜ, the multivariate kernel density estimator

\[ f_{h,k}(x) = \frac{C_{d} \cdot h}{\pi^{d} / 2} \prod_{i=1}^{d} k \left( \frac{||x-x_{i}||}{h} \right) \] (1)

where g(r) = r⁻₅ and n is the number of neighbors taken into account which has five dimension sample domain. We use combined kernel function where hₚ and hᵣ are different bandwidth values for spatial domain and range domain, respectively. The vector k(x) defined in (1) is called the mean-shift vector, since it is the difference between the current value x and the weighted mean of the neighbors xᵢ around x. In the mean-shift procedure, the current estimate of the mode yₖ at iteration k is replaced by its locally weighted mean

\[ y_{k+1} = y_{k} + m(y_{k}) \] (2)

C. Wound Boundary Determination and Analysis

Based on screen resolution, skin color feature and foot outline detection; the proposed wound boundary determination method is illustrated below as in Fig 2. The Largest connected component detection is first performed on the segmented image, using the fast largest connected component detection method introduced in [16] including two passes.
Fig 2: Largest Connected Region

After segmentation they will search for largest connected region based on homogeneous color values. Then they will go for color thresholding, in that they will differentiate the wound color from the background color, which helps them in determining the wound properly.

The Foot outline detection is performed by finding the largest connected component in the segmented image under the condition that the color of this component is similar enough to a preset standard skin color. Based on the standard color checkers provided in [20], both the light and dark skin color thresholds in CIE LAB space are incorporated into this system, which means that this algorithm is expected to work for most skin colors.

CIE L*a*b* (CIELAB) is a color space specified by the International Commission on Illumination. It describes all the colors visible to the human eye and was created to serve as a device-independent model to be used as a reference. The three coordinates of CIELAB represent the lightness of the color (L* = 0 yields black and L* = 100 indicates diffuse white; specular white may be higher), its position between red/magenta and green (a*, negative values indicate green while positive values indicate magenta) and its position between yellow and blue (b*, negative values indicate blue and positive values indicate yellow). The asterisk (*) after L, a and b are pronounced star and are part of the full name, since they represent L*, a* and b*, to distinguish them from Hunter's L, a, and b, described below.

Since the L*a*b* model is a three-dimensional model, it can be represented properly only in a three-dimensional space. Two-dimensional depictions include chromaticity diagrams: sections of the color solid with a fixed lightness. It is crucial to realize that the visual representations of the full gamut of colors in this model are never accurate; they are there just to help in understanding the concept.

Because the red-green and yellow-blue opponent channels are computed as differences of lightness transformations of cone responses, CIELAB is a chromatic value color space.

There are no simple formulas for conversion between RGB or CMYK values and L*a*b*, because the RGB and CMYK color models are device-dependent. The RGB or CMYK values first must be transformed to a specific absolute color space, such as RGB or Adobe RGB. This adjustment will be device-dependent, but the resulting data from the transform will be device-independent, allowing data to be transformed to the CIE 1931 color space and then transformed into L*a*b*.

IV. EXPERIMENTAL RESULTS

The goal of the experimental work has been done:
1) to assess the accuracy of the wound boundary determination based on the mean-shift algorithm and the color segmentation based on the mean shift algorithm;
2) to perform an efficiency color feature extraction and analysis the healing status of the wound in a foot area by comparing the values to the CIE LAB values.
consistent, simple assessment model to evaluate wounds [11]. It
classifies wound tissues within a wound as red, yellow, black or
mixed tissues, which represent the different phases of the wound
healing process. Specifically, red tissues are viewed as the
inflammatory (reaction) phase, proliferation (regeneration), or
maturation (remodelling) phase; yellow tissues imply infection
or tissue containing slough that are not ready to heal; and black
tissues indicate necrotic tissue state, which is not ready to heal
either [11], [17]. Based on the RYB wound evaluation model, our
wound analysis task is to classify all the pixels within the wound
boundary into the RYB color categories and cluster them.
Therefore, classical clustering methods can be applied to solve
this task.

V. CONCLUSION

The goal of proposed system is to provide good wound image
analysis through system. The wound image analysis algorithm is
implemented. We use the mean shift based boundary
determination algorithm to analysis of accurate wound boundary
detection result. In this technique patients are active participants
in their own care. For each individual patient manually find an
optimal parameter setting based on single sample image taken
from the patient before the practical application. The wound
analysis systems whereby clinicians can remotely access the
wound image and result .All result are store in database.
Patient’s travel exposure is considerably reduced. Also it will
reduce the patients stress. Doctor can easily analyze the problem
through images and its segmentation. The proper report can be
given to the patient on time. It avoids high cost, complexity, and
lack of tissue classification. It is easy to use device for self-
management of foot ulcer for patients with diabetes. The image
segmentation can be determining the outline of foot ulcer and
accurate wound area are detect. The processing algorithms are
both accurate and well suited for the available hardware and
computational resources that time Patient for image capture and
image processing provided. For real-time wound analysis that
design is highly efficient and accurate algorithm for this process.
So future plan is to apply machine learning methods is to train
the wound analysis system based on clinical input and thereby
achieve better boundary determination results with less
restrictive assumptions. Furthermore, plan is to compute a
healing score to be assigned to each wound image to support
trend analysis of a wound’s healing status.

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